

CLAIMS

What is claimed is:

1. A process for the separation and isolation of a nanoparticle comprising a defined number of ligands, the process comprising the steps of:
  - a) providing a population of nanoparticles having a narrow uniform size distribution, wherein a subset of the population has at least one ligand stably affixed to the nanoparticle to form a nanoparticle-ligand complex, wherein the minimum effective size of said complex is at least twice the effective size of the isolated nanoparticle;
  - b) applying the population of nanoparticles of (a) to a size exclusion chromatographic medium having an effective size cutoff greater than the nanoparticle-ligand complex; and
  - c) collecting nanoparticle-ligand complexes having a defined number of ligands.
2. A process according to Claim 1 wherein the population of nanoparticles contain nanoparticles ranging from about 2nm to about 10nm in diameter.
3. A process according to Claim 1 wherein the nanoparticle is metallic.
4. A process according to Claim 3 wherein the metal comprising the nanoparticle is selected from the group consisting of gold, silver, platinum, palladium, iridium, rhodium, osmium, iron, copper, cobalt, and alloys thereof.
5. A process according to Claim 1 wherein the nanoparticle is a semiconductor.
6. A process according to Claim 5 wherein the semiconductor comprising the nanoparticle is selected from the group consisting of cadmium selenide, cadmium sulfide, silver sulfide, cadmium sulfide, zinc sulfide, zinc selenide, lead sulfide, gallium arsenide, silicon, tin oxide, iron oxide, and indium phosphide.
7. A process according to Claim 1 wherein the nanoparticle is coated with a monolayer.
8. A process according to Claim 7 wherein said monolayer is selected from the group consisting of:

- a) molecules having reactive groups selected from the group consisting of:  $\text{-NH}_2$ ,  $\text{-COOH}$ ,  $\text{-CHO-}$ ,  $\text{-OH}$ ,  $\text{-X}$  (Cl, Br, I), succinimide, and epoxy groups; and
- b) biomolecules selected from the group consisting of:  
5 peptides; tiopronin and GSH.
9. A process according to Claim 7 wherein said monolayer further comprises a shielding component.
10. A process according to Claim 9 wherein the shielding component is selected from the group consisting of short chain ethylene glycol oligomers, ethylene glycol methacrylate, sugars, crown ethers, and acrylamide.
11. A process according to Claim 1 wherein the ligand is selected from the group consisting of proteins, nucleic acids, peptide nucleic acids, synthetic polymers and oligomers.
- 15 12. A process according to Claim 11 wherein the ligand is a nucleic acid molecule.
13. A process according to Claim 12 wherein the nucleic acid molecule is from about 10 to about 100 bases.
14. A process according to Claim 12 wherein the nucleic acid  
20 molecule is from about 20 to about 50 bases.
15. A process according to Claim 12 wherein the nucleic acid molecule is derivatized at the 5' or 3' end to comprise functional groups.
16. A process according to Claim 15 wherein said functional groups are selected from the group consisting of: SC6H12, amine group( $\text{-NH}_2$ )  
25 with 1 to 12 carbon spacers, thiol groups (SH) with 1 to 12 carbon spacers, biotin groups with 1 to 12 carbon spacers; triethylene glycol spacers, acrylamide groups with 1 to 12 carbon spacers.
17. A process according to Claim 15 wherein said functional group is a member of a binding pair.
- 30 18. A process according to Claim 17 wherein said member of a binding pair is selected from the group consisting of Glutathione-S-transferase/glutathione, 6X Histidine Tag/Ni-NTA, Streptavidin/biotin, S-protein/S-peptide, Cutinase/phosphonate inhibitor, antigen/antibody, hapten/anti-hapten, folic acid/folate binding protein, and protein A or  
35 G/immunoglobulins.
19. A process according to Claim 1 wherein the size exclusion chromatography medium is carbohydrate based.

20. A geometric nanostructure comprising at least three nanoparticle-ligand complexes, said complexes each comprising:

- a) a nanoparticle;
- b) a ligand having a first proximal portion and a second distal portion;

wherein the ligand is affixed to the surface of the nanoparticle at the first proximal portion; and

wherein the nanoparticle-ligand complexes are each affixed to each other through the second distal portion of the ligand.

21. A geometric nanostructure according to Claim 20 wherein the nanoparticle has a diameter of about 2nm to about 10nm.

22. A geometric nanostructure of Claim 20 wherein the nanoparticle is comprised of materials selected from the group consisting of metals and semiconductors.

23. A geometric nanostructure of Claim 20 wherein the ligand is selected from the group consisting of proteins, nucleic acids, peptide nucleic acids, synthetic polymers and oligomers.

24. A geometric nanostructure of Claim 23 wherein the ligand is a nucleic acid containing molecule selected from the group consisting of nucleic acids and peptide nucleic acids.

25. A geometric nanostructure of Claim 24 wherein the ligand is derivatized to include a functional group at the distal portion.

26. A geometric nanostructure of Claim 25 wherein the functional group is selected from the group consisting of SC6H12, amine group(-NH2) with 1 to 12 carbon spacers, thiol groups (SH) with 1 to 12 carbon spacers, biotin groups with 1 to 12 carbon spacers; triethylene glycol spacers, acrylamide groups with 1 to 12 carbon spacers.

27. A geometric nanostructure of Claim 20 wherein the ligand is a nucleic acid molecule and the nanoparticle-ligand complexes are affixed to each other through the hybridization of the distal portions of the ligand.

28. A geometric nanostructure of Claim 20 wherein the functional group is a first member of a binding pair and wherein the nanoparticle-ligand complexes are each affixed to a second member of a binding pair.

29. A geometric nanostructure of Claim 28 wherein the first member of a binding pair is biotin and wherein the second member of a binding pair is selected from the group consisting of avidin and streptavidin.

30. A geometric nanostructure comprising at least two nanoparticle-ligand complexes, said complexes each comprising:

- a) at least one nanoparticle; and
- b) at least one ligand having a first proximal portion and a  
5 second distal portion;

wherein the ligand is affixed to the surface of the nanoparticle at the first proximal portion; and

wherein the nanoparticle-ligand complexes are each affixed to each other through the second distal portion of the ligand, and take the  
10 forms of dimers, trimers, tetramers and mixtures thereof.

31. A geometric nanostructure according to Claim 30 wherein the nanoparticle has a diameter from about 2nm to about 10nm.